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Hauck et al.

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(54) **SERVICE PROVIDER ACTIVATION WITH SUBSCRIBER IDENTITY MODULE POLICY**

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H04W 8/26	(2009.01)

(52) **U.S. Cl.**

CPC ***H04W 8/265*** (2013.01)
USPC **455/558**

(58) **Field of Classification Search**

USPC 455/558, 435.1, 418, 419, 411
See application file for complete search history.

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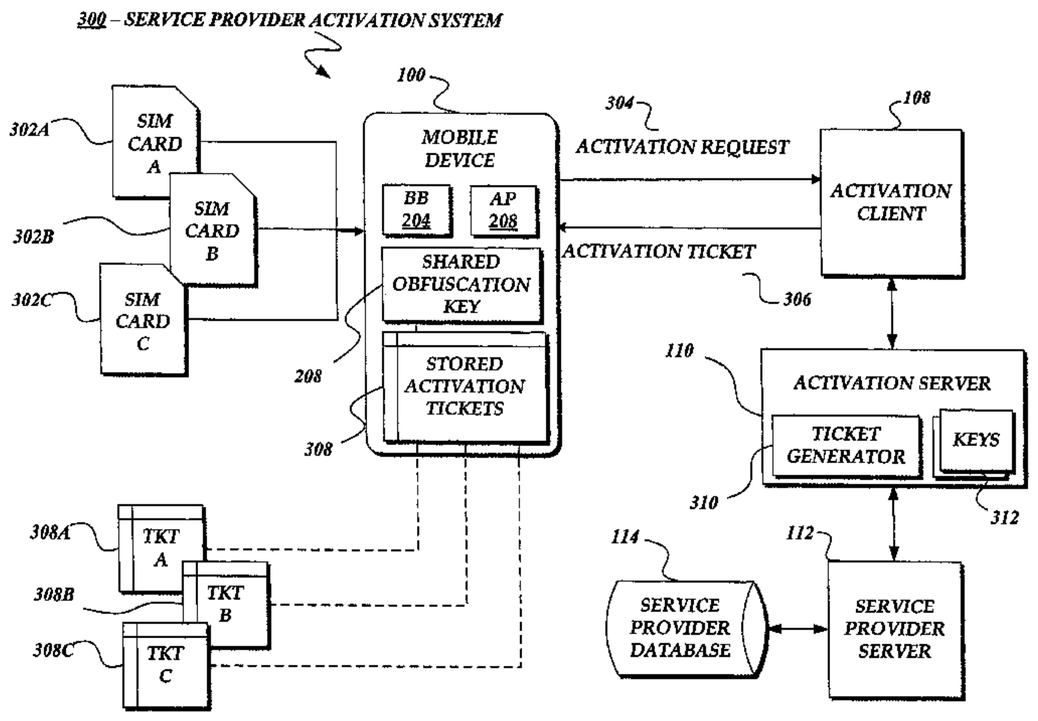
(57) **ABSTRACT**

Systems and methods for activating a mobile device for use with a service provider are described. In one exemplary method, a mobile device having a currently inserted SIM card may be prepared for activation using a signing process in which an activation server generates a signed activation ticket encoded with SIM policy data that corresponds to the combination of the device and one of a number of SIM cards belonging to a set of SIM cards defined by the SIM policy data. The activation ticket is securely stored on the mobile device. In another exemplary method the mobile device may be activated in an activation process in which the device verifies an activation ticket against information specific to the device and SIM card in accordance with the SIM policy in the activation ticket, and initiates activation when the verification of the activation ticket is successful.

20 Claims, 8 Drawing Sheets



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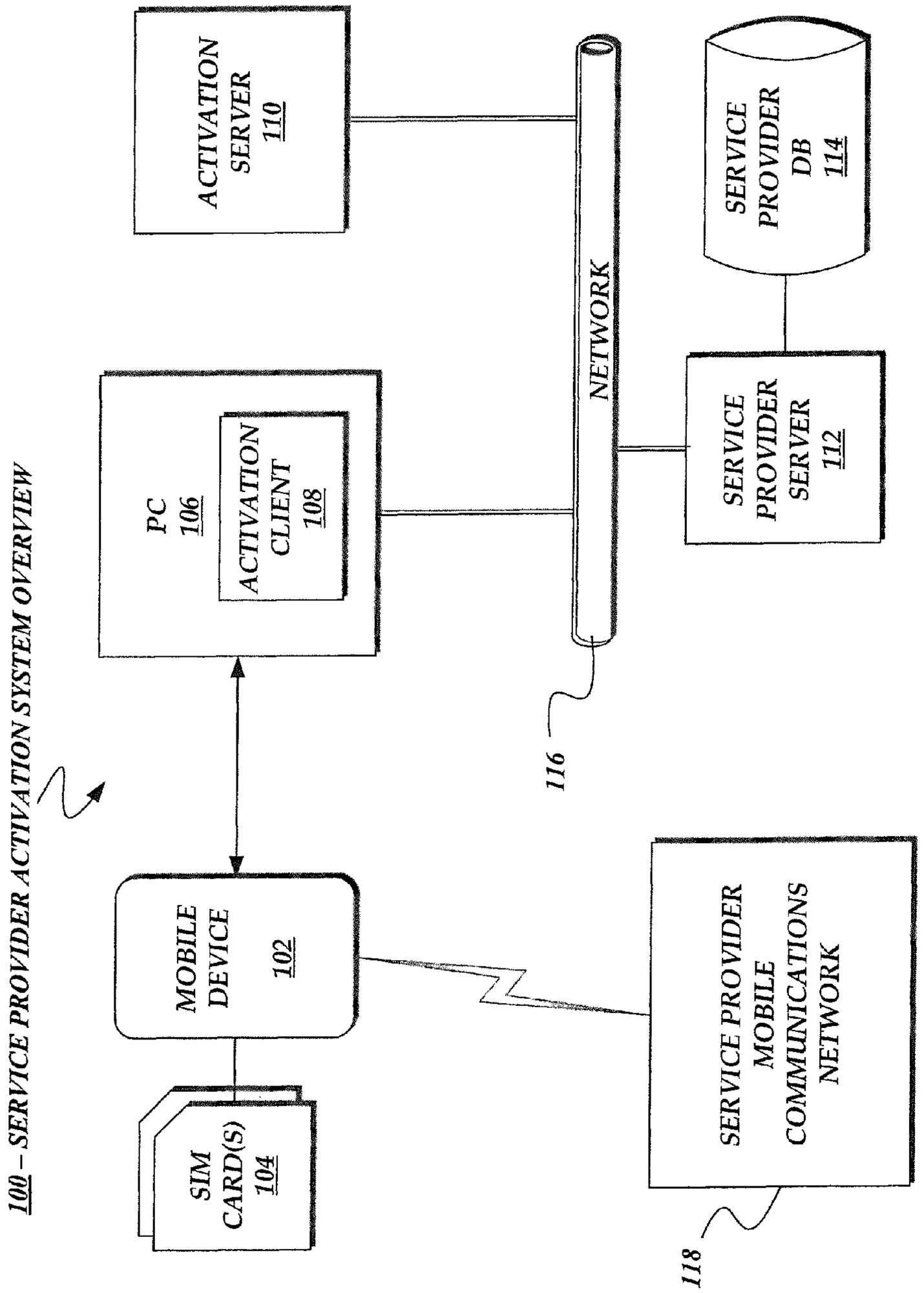
100 – SERVICE PROVIDER ACTIVATION SYSTEM OVERVIEW
ACTIVATION SERVER 110
NETWORK
SERVICE PROVIDER DB 114
PC 106
ACTIVATION CLIENT 108
SERVICE PROVIDER SERVER 112
116
MOBILE DEVICE 102
SIM CARD(S) 104
SERVICE PROVIDER MOBILE COMMUNICATIONS NETWORK
118

Fig. 1.

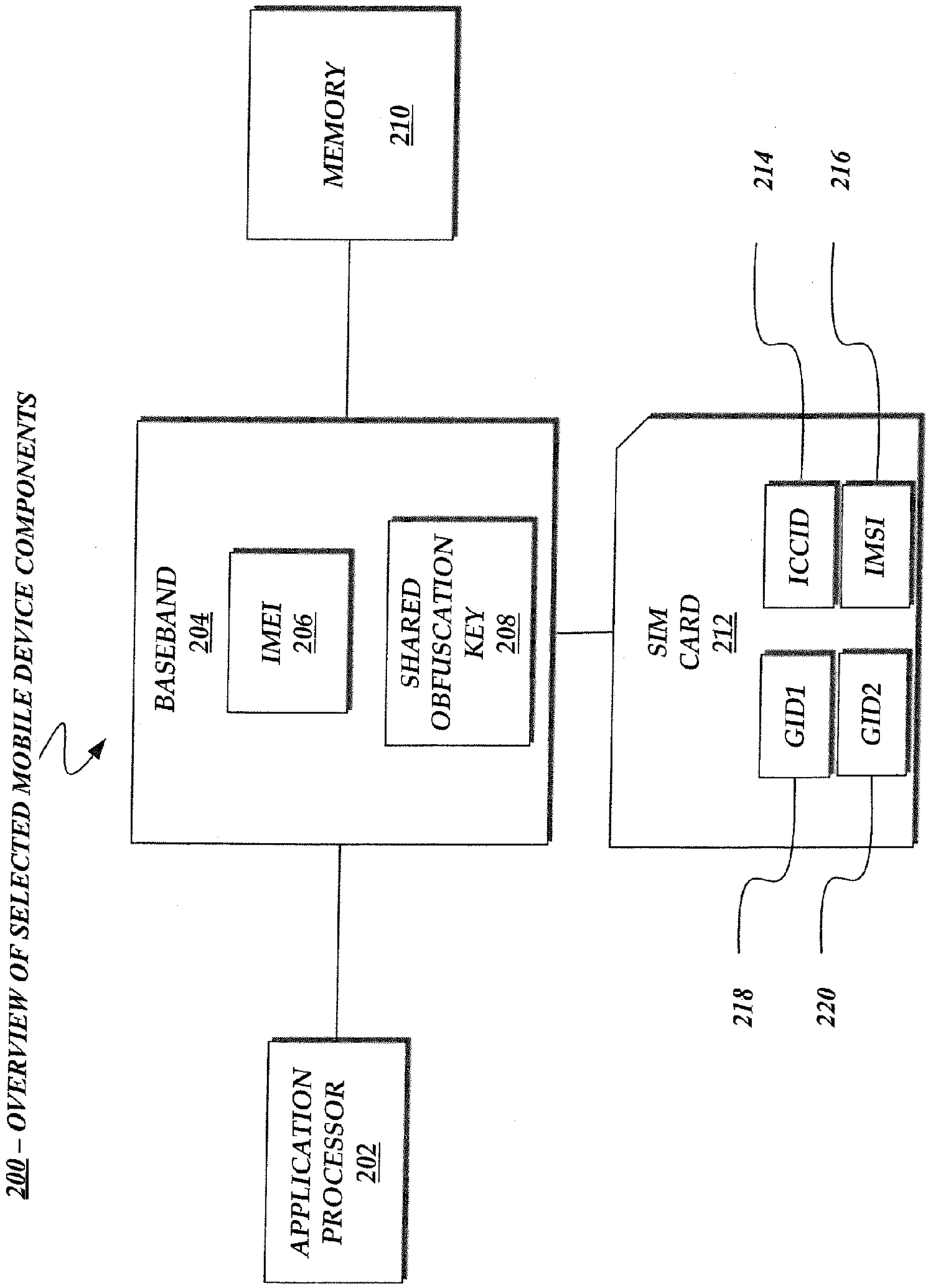
200 – OVERVIEW OF SELECTED MOBILE DEVICE COMPONENTS
APPLICATION PROCESSOR 202
MEMORY 210
BASEBAND 204
IMEI 206
SHARED OBFUSCATION KEY 208
SIM CARD 212
ICCID
IMSI
GID1
GID2
214
216
218
220

Fig. 2.

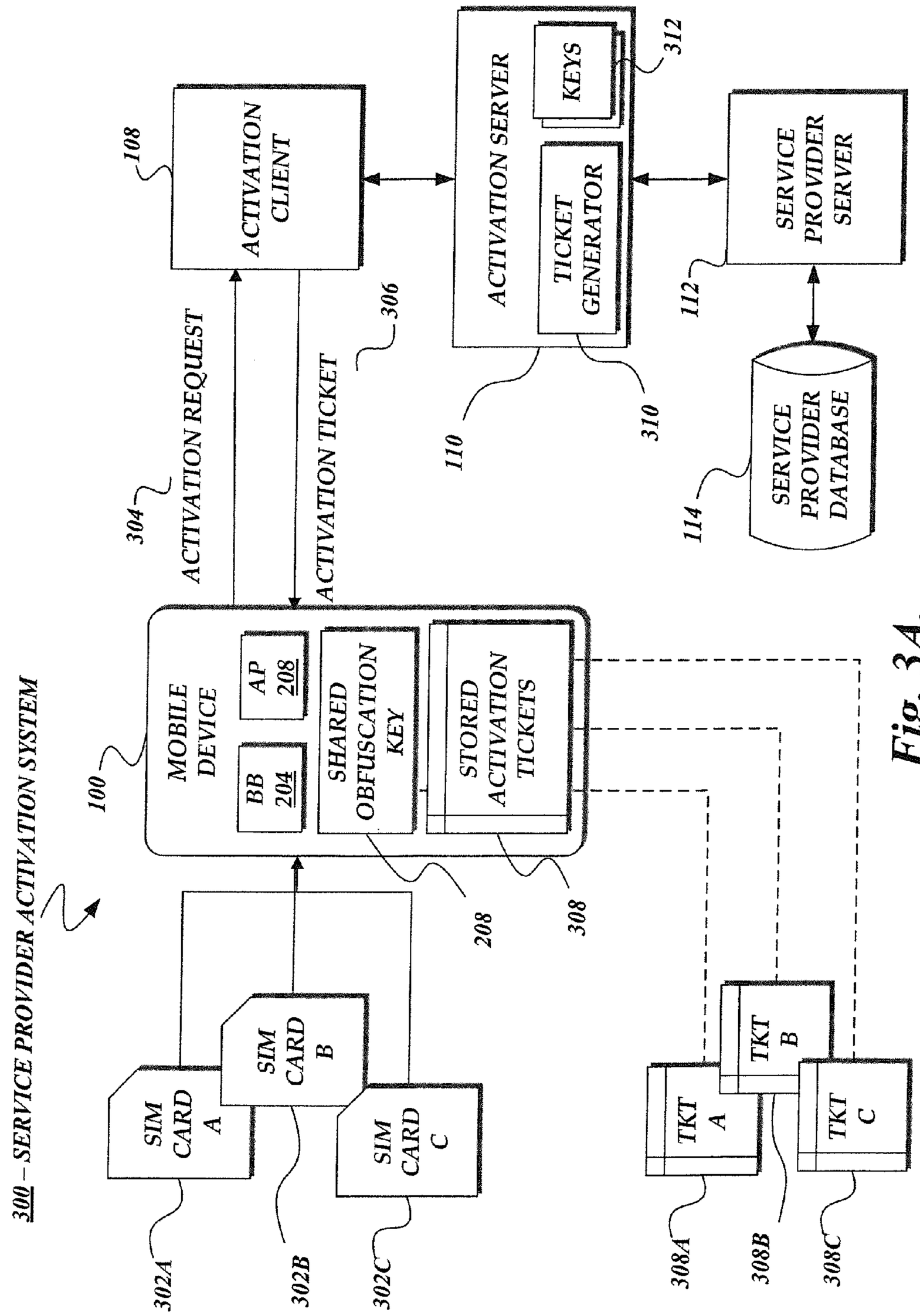
300 – SERVICE PROVIDER ACTIVATION SYSTEM
100
MOBILE DEVICE
BB 204
AP 208
SHARED OBFUSCATION KEY
208
STORED ACTIVATION TICKETS
308
SIM CARD A
SIM CARD B
SIM CARD C
302A
302B
302C
304
ACTIVATION REQUEST
ACTIVATION TICKET
306
108
ACTIVATION CLIENT
ACTIVATION SERVER
KEYS
312
TICKET GENERATOR
110
310
112
SERVICE PROVIDER SERVER
114
SERVICE PROVIDER DATABASE
TKT A
TKT B
TKT C
308A
308B
308C

Fig. 3A.

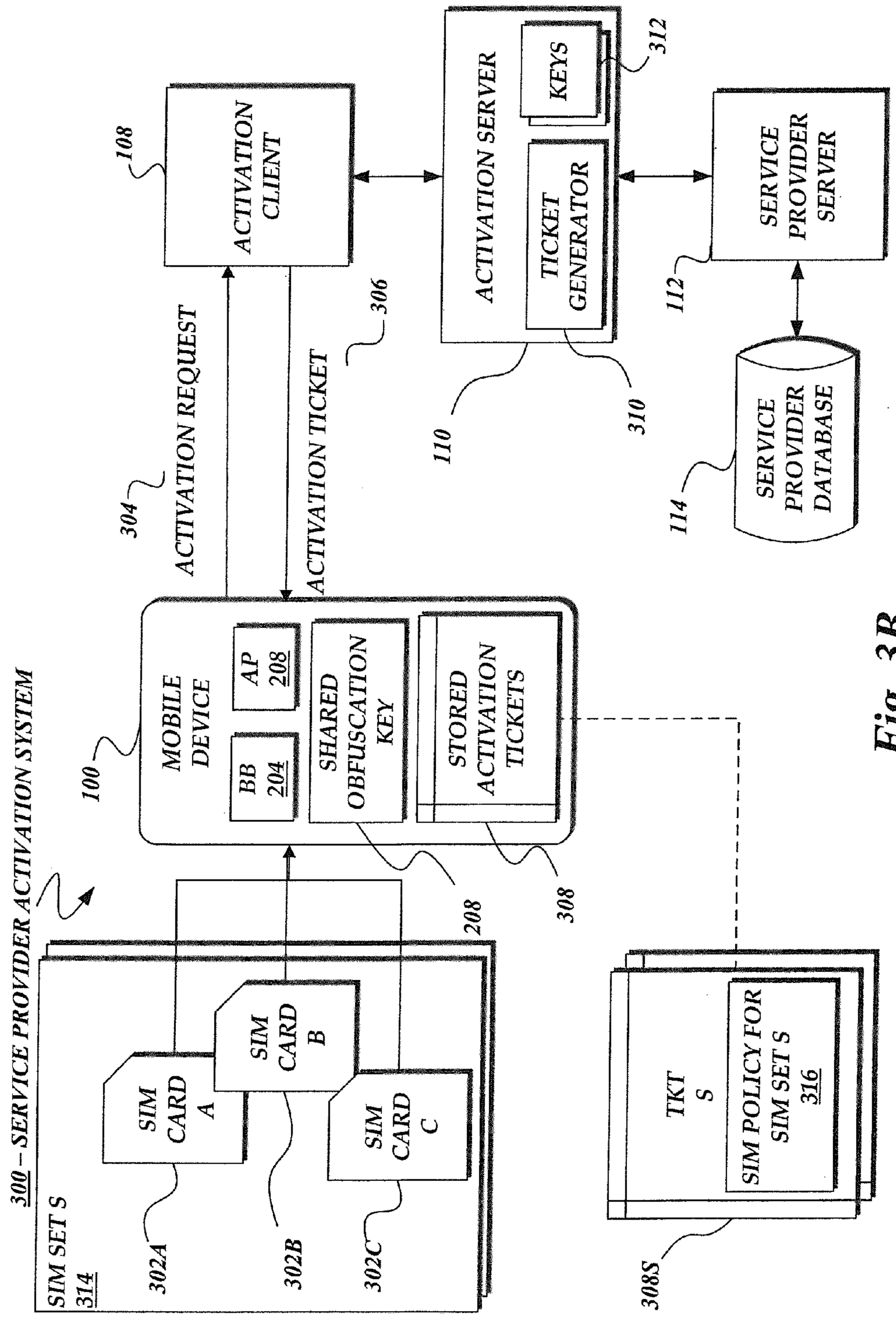
300 – SERVICE PROVIDER ACTIVATION SYSTEM
SIM SET S
314
SIM CARD A
SIM CARD B
SIM CARD C
302A
302B
302C
208
100
MOBILE DEVICE
BB 204
AP 208
SHARED OBFUSCATION KEY
STORED ACTIVATION TICKETS
308
304
ACTIVATION REQUEST
ACTIVATION TICKET
306
108
ACTIVATION CLIENT
ACTIVATION SERVER
KEYS
312
TICKET GENERATOR
110
310
112
SERVICE PROVIDER SERVER
114
SERVICE PROVIDER DATABASE
TKT S
SIM POLICY FOR SIM SET S
316
308S

Fig. 3B.

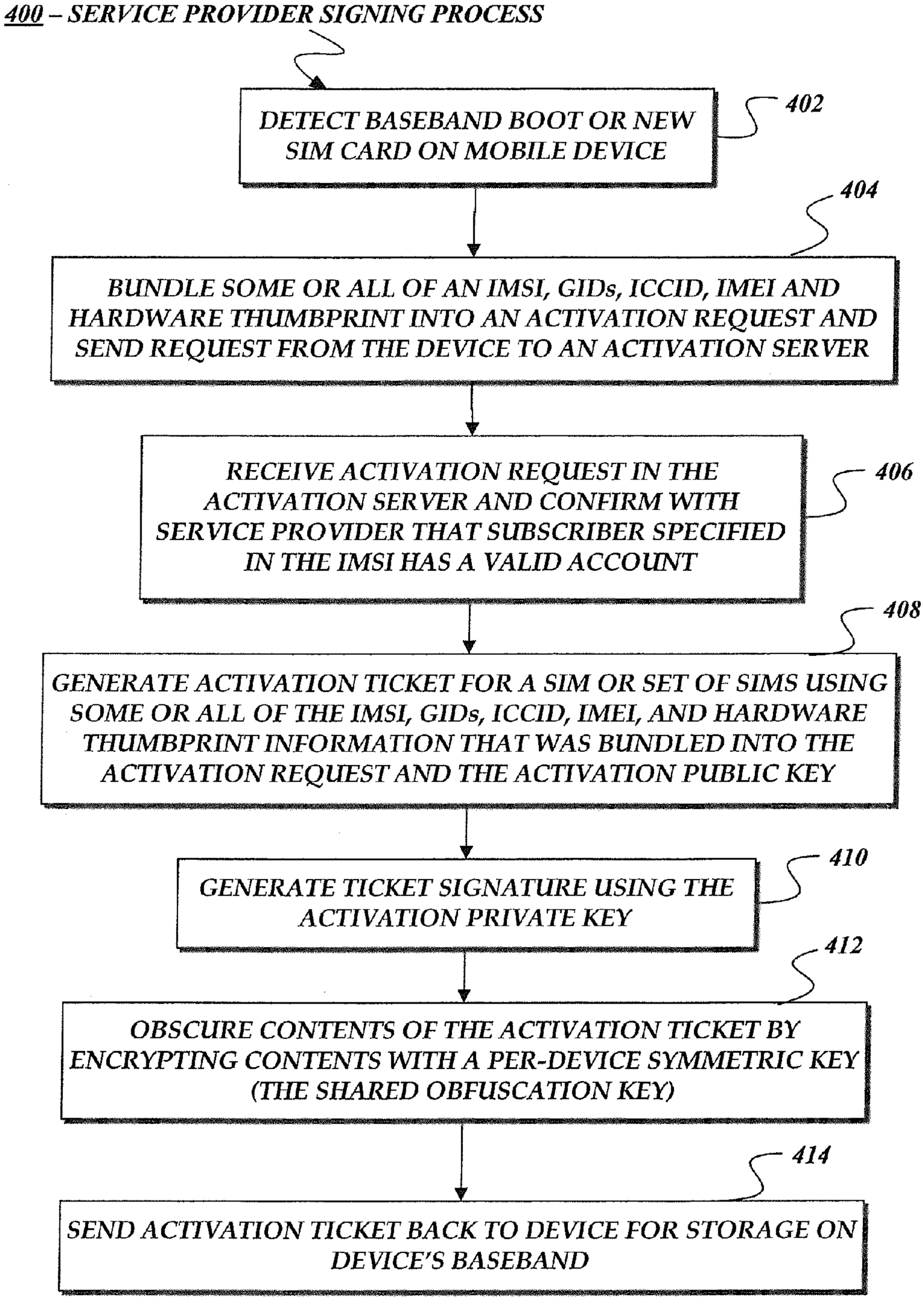
400 – SERVICE PROVIDER SIGNING PROCESS
DETECT BASEBAND BOOT OR NEW SIM CARD ON MOBILE DEVICE
402
404
BUNDLE SOME OR ALL OF AN IMSI, GIDs, ICCID, IMEI AND HARDWARE THUMBPRINT INTO AN ACTIVATION REQUEST AND SEND REQUEST FROM THE DEVICE TO AN ACTIVATION SERVER
RECEIVE ACTIVATION REQUEST IN THE ACTIVATION SERVER AND CONFIRM WITH SERVICE PROVIDER THAT SUBSCRIBER SPECIFIED IN THE IMSI HAS A VALID ACCOUNT
406
408
GENERATE ACTIVATION TICKET FOR A SIM OR SET OF SIMS USING SOME OR ALL OF THE IMSI, GIDs, ICCID, IMEI, AND HARDWARE THUMBPRINT INFORMATION THAT WAS BUNDLED INTO THE ACTIVATION REQUEST AND THE ACTIVATION PUBLIC KEY
GENERATE TICKET SIGNATURE USING THE ACTIVATION PRIVATE KEY
410
412
OBSCURE CONTENTS OF THE ACTIVATION TICKET BY ENCRYPTING CONTENTS WITH A PER-DEVICE SYMMETRIC KEY (THE SHARED OBFUSCATION KEY)
414
SEND ACTIVATION TICKET BACK TO DEVICE FOR STORAGE ON DEVICE'S BASEBAND

Fig. 4.

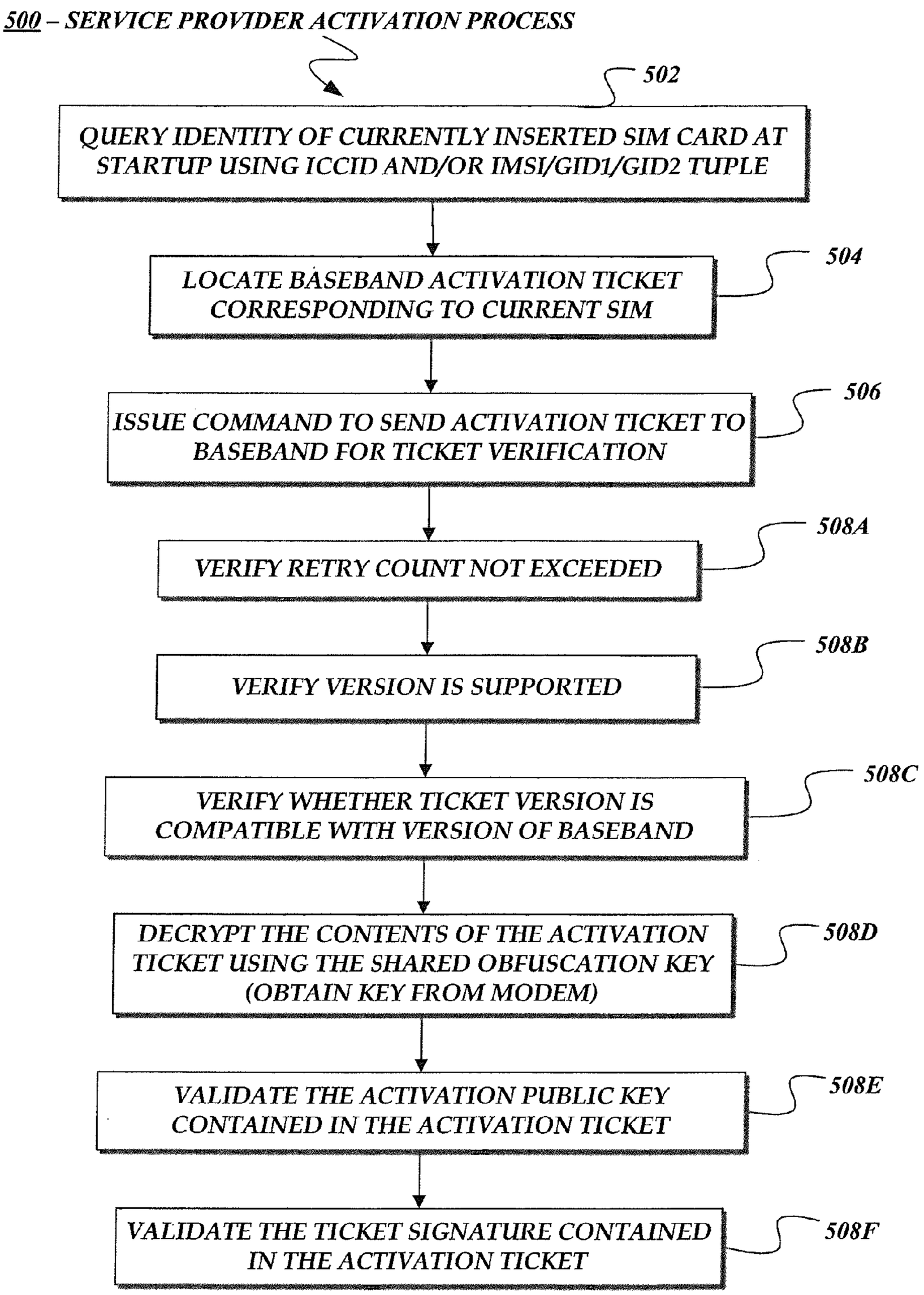
500 – SERVICE PROVIDER ACTIVATION PROCESS
502
QUERY IDENTITY OF CURRENTLY INSERTED SIM CARD AT STARTUP USING ICCID AND/OR IMSI/GID1/GID2 TUPLE
504
LOCATE BASEBAND ACTIVATION TICKET CORRESPONDING TO CURRENT SIM
506
ISSUE COMMAND TO SEND ACTIVATION TICKET TO BASEBAND FOR TICKET VERIFICATION
508A
VERIFY RETRY COUNT NOT EXCEEDED
508B
VERIFY VERSION IS SUPPORTED
508C
VERIFY WHETHER TICKET VERSION IS COMPATIBLE WITH VERSION OF BASEBAND
508D
DECRYPT THE CONTENTS OF THE ACTIVATION TICKET USING THE SHARED OBFUSCATION KEY (OBTAIN KEY FROM MODEM)
508E
VALIDATE THE ACTIVATION PUBLIC KEY CONTAINED IN THE ACTIVATION TICKET
508F
VALIDATE THE TICKET SIGNATURE CONTAINED IN THE ACTIVATION TICKET

Fig. 5A.

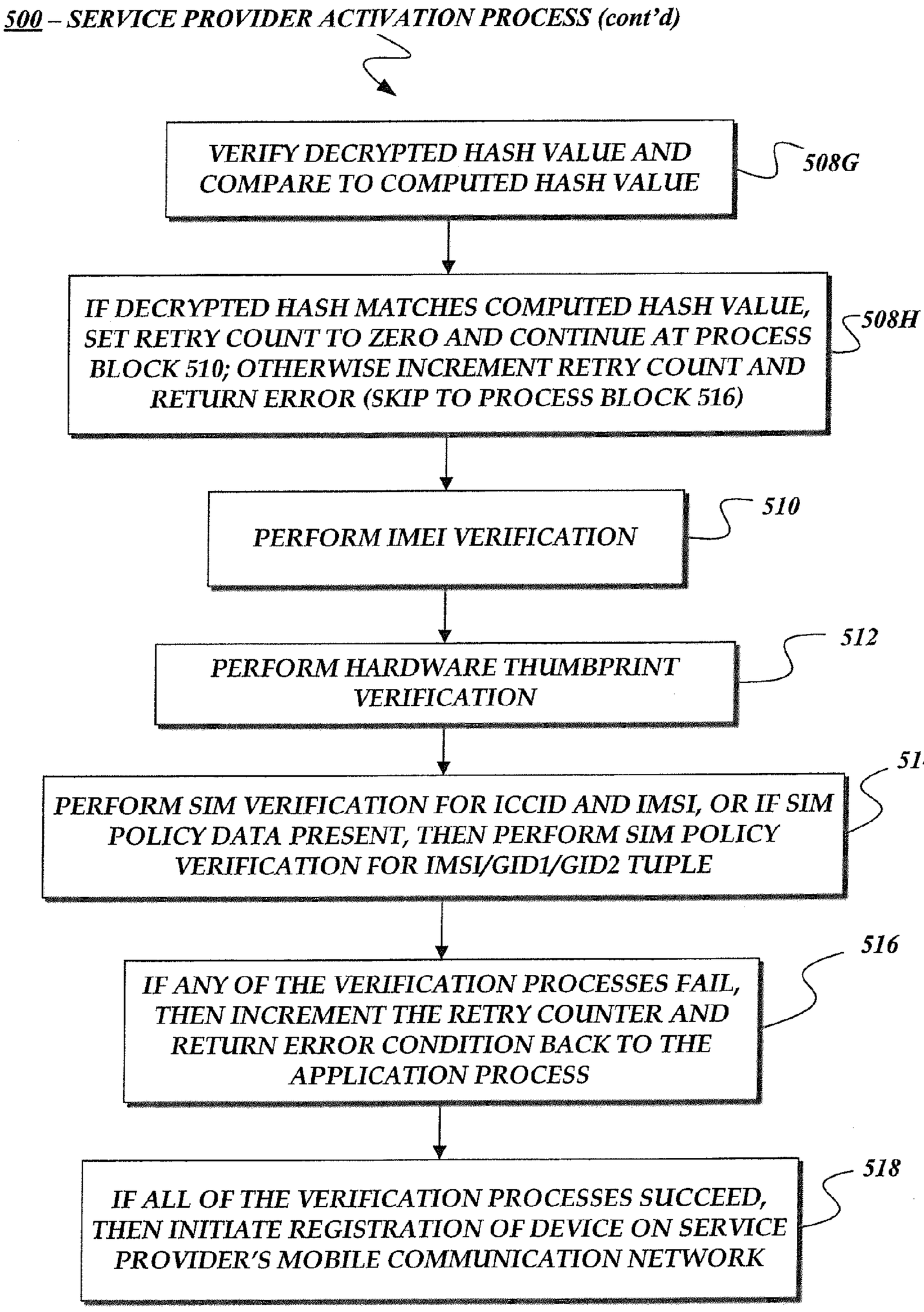
500 – SERVICE PROVIDER ACTIVATION PROCESS (cont'd)
VERIFY DECRYPTED HASH VALUE AND COMPARE TO COMPUTED HASH VALUE
508G
IF DECRYPTED HASH MATCHES COMPUTED HASH VALUE, SET RETRY COUNT TO ZERO AND CONTINUE AT PROCESS BLOCK 510; OTHERWISE INCREMENT RETRY COUNT AND RETURN ERROR (SKIP TO PROCESS BLOCK 516)
508H
PERFORM IMEI VERIFICATION
510
PERFORM HARDWARE THUMBPRINT VERIFICATION
512
PERFORM SIM VERIFICATION FOR ICCID AND IMSI, OR IF SIM POLICY DATA PRESENT, THEN PERFORM SIM POLICY VERIFICATION FOR IMSI/GID1/GID2 TUPLE
514
IF ANY OF THE VERIFICATION PROCESSES FAIL, THEN INCREMENT THE RETRY COUNTER AND RETURN ERROR CONDITION BACK TO THE APPLICATION PROCESS
516
IF ALL OF THE VERIFICATION PROCESSES SUCCEED, THEN INITIATE REGISTRATION OF DEVICE ON SERVICE PROVIDER'S MOBILE COMMUNICATION NETWORK
518

Fig. 5B.

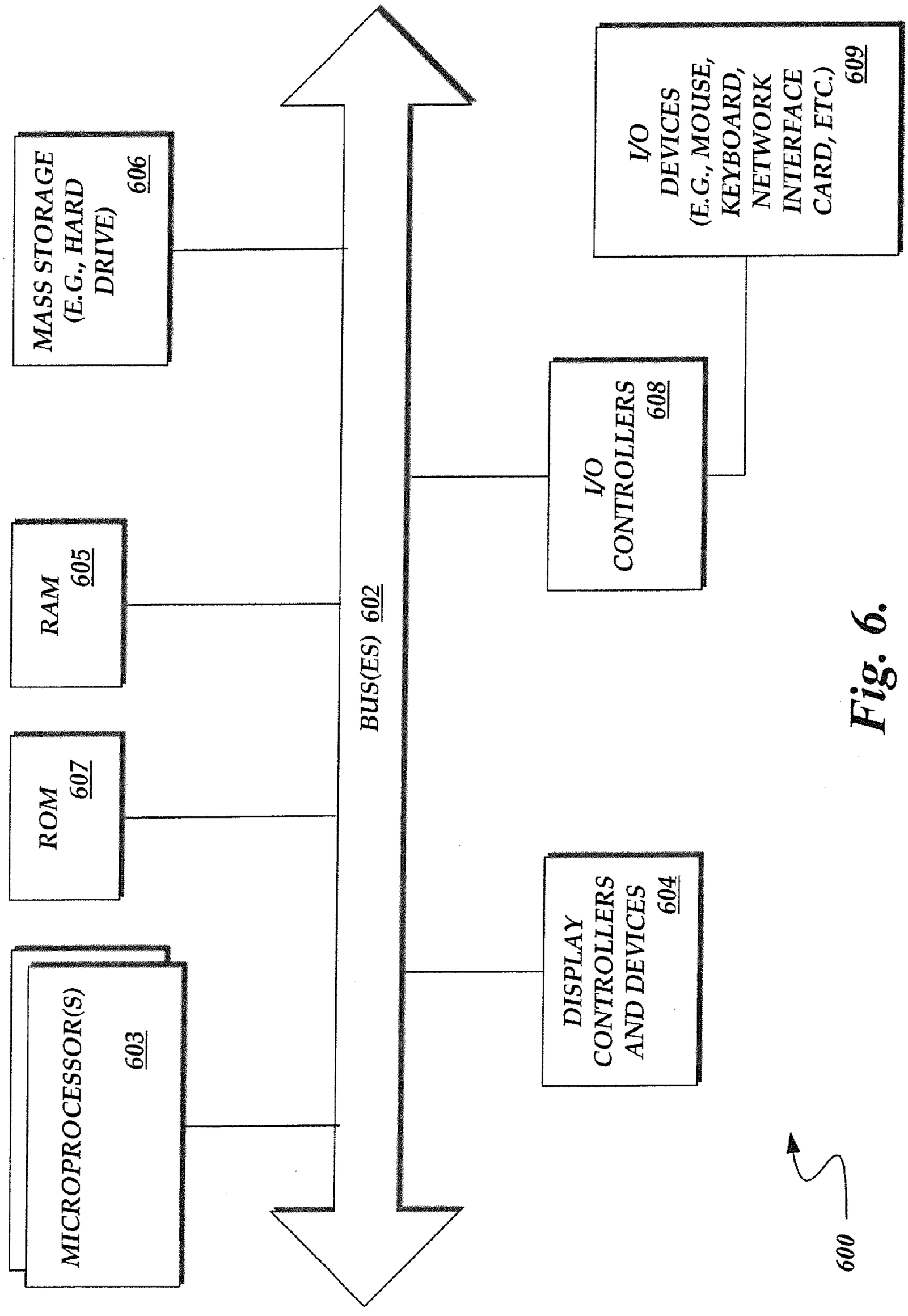
MASS STORAGE (E.G., HARD DRIVE) 606
RAM 605
ROM 607
MICROPROCESSOR(S) 603
BUS(ES) 602
I/O DEVICES (E.G., MOUSE, KEYBOARD, NETWORK INTERFACE CARD, ETC.) 609
I/O CONTROLLERS 608
DISPLAY CONTROLLERS AND DEVICES 604
600

Fig. 6.

SERVICE PROVIDER ACTIVATION WITH SUBSCRIBER IDENTITY MODULE POLICY

CROSS-REFERENCE TO PRIORITY AND RELATED APPLICATIONS

This application is a continuation of and claims priority to co-owned co-pending U.S. patent application Ser. No. 12/014,089 filed Jan. 14, 2008 and entitled "SERVICE PROVIDER ACTIVATION WITH SUBSCRIBER IDENTITY MODULE POLICY", which is a continuation-in-part of U.S. patent application Ser. No. 11/849,286, filed on Sep. 1, 2007, entitled "SERVICE PROVIDER ACTIVATION, each of the foregoing incorporated by reference in its entirety"

BACKGROUND

Mobile devices that are manufactured for use with the Global System for Mobile Communications (GSM) digital cellular phone technology are designed to work with any mobile communications network service provider. The device requires the use of a subscriber identity module (SIM), referred to as a SIM card, which must be inserted into the GSM device to sign on to the subscriber's service provider network. The SIM card is a small circuit board that contains, among other things, an identifier that identifies the service provider with which the SIM card is allowed to be used. Typically, each service provider, such as AT&T, or Verizon, is assigned their own range of SIM card identifiers for use with their networks.

Most GSM devices are manufactured with a service provider lock that restricts the device to SIM cards for a particular service provider. For example, a mobile device manufactured by Nokia that is marketed by an AT&T service provider may have a lock that restricts the device to SIM cards encoded with identifiers falling within the range of SIM card identifiers assigned for use with the AT&T network.

The method of enforcing the service provider lock may vary from one manufacturer to the next. When a device is manufactured with a service provider lock, the lock is usually based on a code that is stored in the device or derived using an algorithm. However, the codes and/or algorithms may be compromised such that the device may be unlocked and used with SIM cards having identifiers assigned for use with other service providers. This results in a loss of revenue for the original service provider, since the device is, presumably, no longer being used on their network.

From the GSM device manufacturer's point of view, there are other drawbacks to manufacturing devices with service provider locks. For example, manufacturing a device with a particular service provider lock may require the manufacturer to maintain different part numbers for the mobile devices manufactured for the different service providers, since the locking codes and/or algorithms will vary depending on the service provider. This can add to the logistical complexity of manufacturing the device as well as add significant inventory cost.

From the consumers' point of view, most would likely prefer the freedom of purchasing a mobile device without being restricted to one particular service provider. For example, it may be desirable to switch to a different service provider when traveling abroad or to different parts of the country.

SUMMARY OF THE DETAILED DESCRIPTION

Methods and systems for service provider activation in a mobile device are described.

According to one aspect of the invention, a mobile device operates in limited service mode until activated for use with a particular service provider. The mobile device may be prepared for activation through the use of a service provider signing process, and subsequently activated for use with a particular service provider through the use of a service provider activation process. The service provider signing and activation processes are performed in accordance with embodiments of the invention.

According to one aspect of the invention, the service provider signing process prepares the device for activation by causing an activation ticket to be stored on the device that securely incorporates information from both the device and the SIM card that is inserted into the device during the signing process.

According to another aspect of the invention, the service provider activation process verifies that an activation ticket previously stored on the device is authentic and corresponds to both the device and the SIM card currently inserted into the device prior to activating the device for use on the service provider's network.

According to one aspect of the invention, when a new SIM card is inserted into the device, or when the device is rebooted, the service provider signing and activation processes are repeated as necessary to activate the device for use with the service provider identified in the currently inserted SIM card. For example, when the currently inserted SIM card has already undergone the signing process during a previous insertion into the device, or when the currently inserted SIM card belongs to a set of SIM cards for which an activation ticket has already been stored on the device, then only the activation process is needed to activate the device. When the SIM card is new to the device (i.e., has not yet been through either the signing or activation process on this device, or does not belong to a set of SIM cards for which an activation ticket has already been stored on the device), both the signing and activation processes are repeated to activate the device for use with the service provider.

According to one aspect of the invention, the service provider signing process may be repeated for different SIM cards such that more than one activation ticket may be stored on the device. Each activation ticket stored on the device may correspond to one of the SIM cards that were inserted into the device during the signing process. In some cases, an activation ticket stored on the device corresponds to a set of SIM cards, where at least one of the SIM cards belonging to the set was inserted into the device during the singing process. In this manner, the mobile device may be prepared for activation with different service providers corresponding to the different SIM cards used during the signing process (as long as the subscriber accounts with those service providers are still valid at the time of activation).

According to one aspect of the invention, the service provider signing process includes generating an activation request into which information is bundled from both the device and the SIM card currently inserted into the device. The bundled information includes, among other data, the Integrated Circuit Card ID (ICCID), the International Mobile Subscriber Identifier (IMSI) and/or the group identifiers (GIDs), if any, of the SIM card currently inserted into the device, the International Mobile Equipment Identifier (IMEI) encoded on the device, and a hardware thumbprint of the device.

According to one aspect of the invention, the service provider signing process further includes receiving the activation request in an activation server, where the activation request is typically relayed to the activation server via an activation

client in communication with the device. The activation server generates the activation ticket based on the information that was bundled into the activation request. The activation server, in communication with backend servers for the service provider, may first verify whether the subscriber specified in the IMSI is associated with a valid account. In some embodiments, the activation server may perform other policy determinations that govern whether to generate an activation ticket, including such things as confirming whether the mobile country code (MCC) and mobile network code (MNC) specified in the IMSI is consistent with the expected distribution channel for the device, based on the device's IMEI.

According to one aspect of the invention, during the signing process, the activation server may in some cases generate an activation ticket with a SIM policy encoded on the ticket to describe a set of SIM cards that are allowed to be used with the device. The SIM policy typically applies to the SIM card currently inserted into the device, as well as other SIM cards having IMSI values within a certain range of values, such as those having a certain mobile country code (MCC) and or mobile network code (MNC), and SIM cards having certain group identifiers (GIDs). The SIM policy may be encoded in the activation ticket in various forms, such as an array of rules from which an identifier set of SIM cards that are allowed to be used with the device may be derived. The array of rules may, for example, comprise one or more primitive sets, the members of which may be included or excluded from the identifier set of SIM cards that are allowed to be used with the device. In some cases, the activation server may encode the rules of the SIM policy in the activation ticket in a particular order to facilitate the description of the identifier set of SIM cards in cooperation with logic on the mobile device for evaluating the SIM policy and enforcing the rules.

According to one aspect of the invention, during the signing process, the activation server generates a signed activation ticket using an activation private key that is stored on, or is otherwise accessible by, the activation server. The generated activation ticket is formatted to include not only the information that was bundled into the activation request, but also an activation public key that will later be used on the device to validate the signature of the ticket. As a further security measure, the content of the activation ticket is obscured using encryption before sending the activation ticket back to the device. Encryption may be performed using a per-device symmetric key that is stored on, or is otherwise accessible by, both the device and the activation server. This key may be referred to as the shared obfuscation key.

According to one aspect of the invention, at the conclusion of the signing process, the generated activation ticket is received in the device from the activation server, typically via an activation client in communication with the device. The device stores the activation ticket for use during a subsequent service provider activation process.

According to one aspect of the invention, the service provider activation process queries the ICCID of the currently inserted SIM at startup and uses this value to determine whether an activation ticket has previously been stored for this SIM card. In some cases, the activation ticket may include a SIM policy, in which case the service provider activation process instead evaluates whether the currently inserted SIM card is one of a set of SIM cards with which the mobile device is allowed to be used based on a tuple of identifiers in the SIM card, including the IMSI and group identifier values, GID**1** and/or GID**2**. If an activation ticket has previously been stored, then the service provider activation process issues a command in the device to verify the activation ticket, including but not limited to, decrypting the activation ticket using the shared obfuscation key, validating the public activation key supplied in the ticket by the activation server, and using the validated key to validate the signature of the activation ticket.

According to one aspect of the invention, the service provider activation process verifies the content of the activation ticket against the device and the SIM card currently inserted into the device, including verifying that the IMEI and hardware thumbprints match those in the device, and that the ICCID and IMSI match those in the currently inserted SIM card. When available, the service provider activation process verifies SIM policy encoded in the activation ticket against the IMSI and GID values of the SIM card currently inserted in the device. If the content and/or SIM policy of the activation ticket cannot be verified as matching the device and SIM card, then the activation ticket is treated as invalid, and the device is not activated for use with the service provider's network. If the content and or SIM policy of the activation ticket is verified, then the device is activated for use with the service provider's network.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings in which like references indicate similar elements.

FIG. **1** is a block diagram overview of one architecture for a service provider activation system according to one exemplary embodiment of the invention.

FIG. **2** is a block diagram overview of selected components of a mobile device according to one exemplary embodiment of the invention.

FIGS. **3**A-**3**B are block diagram overviews of a service provider activation system according to one exemplary embodiment of the invention.

FIG. **4** is a flow diagram illustrating certain aspects of performing a method for a service provider signing process according to one exemplary embodiment of the invention.

FIGS. **5**A-**5**B are flow diagrams illustrating certain aspects of performing a method for a service provider activation process according to one exemplary embodiment of the invention.

FIG. **6** is a block diagram overview of an exemplary embodiment of a general purpose computer system in which certain components of a service provider activation system may be implemented according to one exemplary embodiment of the invention, including but not limited to, components such as the activation client, activation server, and other back end servers of the service providers of mobile communications networks.

DETAILED DESCRIPTION

The embodiments of the present invention will be described with reference to numerous details set forth below, and the accompanying drawings will illustrate the described embodiments. As such, the following description and drawings are illustrative of embodiments of the present invention and are not to be construed as limiting the invention. Numerous specific details are described to provide a thorough understanding of the present invention. However, in certain instances, well known or conventional details are not described in order to not unnecessarily obscure the present invention.

The description may include material protected by copyrights, such as illustrations of graphical user interface images.

Various different system architectures may be used to implement the functions and operations described herein, such as to perform the methods shown in FIGS. **4**, **5**A-**5**B. The following discussion provides one example of one such architecture, but it will be understood that alternative architectures may also be employed to achieve the same or similar results. The service provider locking system **100** shown in FIG. **1** is one example which is based upon the iPhone device sold by Apple, Inc. and back end clients and servers associated with the iPhone device and the mobile communication networks with which the iPhone device may be used. It should be understood, however, that the architecture **100** may differ and may further be used with devices and mobile communication networks not related to the iPhone device. The architecture **100** includes a mobile device **102**, such as the iPhone device, and one or more SIM cards **104** which may be inserted into the mobile device **102**. The SIM cards **104** enable the device to register with and use a mobile communications network **118** operated by a service provider associated with one of the SIM cards **104** and/or the device **102**.

The mobile device **102** may further communicate with an activation client **108** operating on a personal computer (PC) **106** or other type of computing device to which the device **102** is connected. The activation client **108** is in communication with one or more activation servers **110**, typically over a network **116**. The network **116** may be any private or public internetwork or other type of communications path over which communications between the activation client **108** and activation server **110** may be transmitted. The activation server **110** may, in turn, be in communication with back end servers **112** of the service provider and a service provider database **114** that may contain information regarding the subscribers and devices that are allowed to register with and use the service provider's mobile communications network **118**.

FIG. **2** is a block diagram overview of selected components **200** of a mobile device **100** according to one exemplary embodiment of the invention. The mobile device **100** may include an application processor (AP) **202** that is used to perform some of the functions of the service provider activation system in accordance with an embodiment of the invention. The AP **202** is typically implemented as firmware that operates in conjunction with a baseband (BB) **204** integrated circuit. Among other things, the BB **204** provides the operating system platform on which the functions of the mobile device are carried out. In a typical embodiment, the BB **204** incorporates a stored IMEI **206** that uniquely identifies the mobile device, as well as a shared obfuscation key **208**, the use of which will be described in detail with reference to the activation ticket processing below. The device **100** further includes a memory component **210** that includes both volatile and non-volatile memory that may be used to store, among other data, the activation tickets used in the service provider activation system that will be described in further detail below.

The mobile device **100** may further include a SIM card slot into which a SIM card **212** may be inserted. The SIM card **212** may include an ICCID **214** that uniquely identifies the SIM card **212** and an IMSI **216** that designates the subscriber, and which is used to provision the mobile communications network **118** with which the device is to be used. The SIM card **212** may further include one or more group identifiers (GIDs) GID**1** **218** and GID**2** **220** that for policy purposes may, together with the IMSI **216**, uniquely identify a SIM card **212** that belongs to a set of SIM cards that are allowed to be used on the mobile device **100** in accordance with a particular SIM policy as will be described in further detail below.

FIG. **3**A is a block diagram overview of a service provider activation system according to one exemplary embodiment of the invention. As illustrated, a mobile device **100** having a BB **294** and an AP **208** may have inserted one of three SIM cards **302**, SIM Card A **302**A, SIM Card B **302**B, and SIM Card C **302**C. FIG. **3**B is another block diagram overview of a service provider activation system according to one exemplary embodiment of the invention, where the SIM cards **302** may be part of a set of SIM cards, SIM SET S **314**, that are subject to a SIM policy as will be described in further detail below. It should be understood that device **100** may be used with any one of a number of SIM cards, and that the three SIM cards are illustrated as an example only.

In one embodiment, the mobile device **100** may be a "generic" device, meaning that it was manufactured without a service provider lock. A device without a service provider lock is usable with any one of SIM cards A, B, and C, **302**A, B, and C. In other embodiments, the mobile device **100** may have been previously locked so that it cannot be used with the SIM cards A, B, and C unless it is first unlocked. Once the device **100** is unlocked, it is generally capable of operating in only a limited service mode, meaning that it can only be used for emergency calls, and is not yet activated on a service provider network.

In one embodiment, upon detecting the insertion of one of the SIM cards A, B, or C, **302**, or, alternatively, when the BB **204** boots, the AP **208** determines whether there is already stored an activation ticket **308** associated with the inserted SIM card A, B, or C. If not, the AP **208** initiates a signing process by issuing an activation request **304** to the activation server **110**. The activation request **304** comprises information from the device **100** and currently inserted SIM card **302**, including, for example, the IMEI, **206** IMSI **216**, ICCID **214**, and/or the GID**1** **218** and GID**2** **220** values, as appropriate, and bundled into the activation request **304**.

In one embodiment, upon receipt of the activation request **304**, the activation server **110** determines whether to generate an activation ticket **306** based on the information that was bundled into the activation request **304**. An activation ticket **306** incorporates identifying information from both the device **100** and the inserted SIM card A, B, or C, using a ticket generator logic **310** and an activation public/private key pair **312** as will be described in further detail with reference to FIG. **4**.

In a typical embodiment, the determination whether to generate an activation ticket **306** will depend, at least in part, on whether the service provider server **112** and/or service provider database **114** indicate that the IMSI **216** bundled into the activation request can be activated on the service provider's communication network **118**. In some embodiments, the determination whether to generate the activation ticket will depend on other policy considerations, such as whether to generate an activation ticket **306** for a given IMEI/ICCID pair (using the IMEI/ICCID that was bundled into the activation request **304**). In one embodiment, the generation of the activation ticket includes the generation of a SIM policy **316** for the SIM SET S **314** of which the currently inserted SIM card A, B, or C, is a member. If the activation server **110** determines that it cannot generate an activation ticket **306**, then the activation request **304** will fail.

In one embodiment, once the activation ticket **306** has been generated, the activation server **110** obfuscates the content of the activation ticket **306** prior to returning the ticket to the device **100** to safeguard the contents of the activation ticket. In one embodiment, the activation ticket **306** is obfuscated by encrypting it with a per-device symmetric key. The per-device symmetric key may be derived from data unique to the device **100** and a key that is shared between the device and the activation server **110**. The shared key is referred to in the illustrated example as a Shared Obfuscation Key **208** on the device **100**, and also stored as one of the Keys **312** defined on the activation server **110**. As an example, the per-device symmetric key is referred to as a Device Obfuscation Key, and is derived using the hardware thumbprint of the device **100** and the Shared Obfuscation Key stored on the server in Keys **312** using the following algorithm:

```
DeviceObfuscationKey = SHA-1(HardwareThumbprint | |
SharedObfuscationKey)
```

After the activation ticket **306** has been generated and encrypted, the activation ticket **306** is ready to be sent back to the device **100**, where it is stored along with any other previously stored activation tickets **308**. The stored activation tickets **308**A, B, and C, can subsequently be used by the AP **208** to initiate the activation process as will be described in further detail with reference to FIGS. **5**A-**5**B.

In one embodiment, alternative formats of the activation ticket **306/308** is as shown in Tables 1A and 1B, where the format in Table 1A is generally used for individual SIM cards not identified as belonging to a set of SIM cards, and the format in Table 1B is generally used for SIM cards identified as belonging to a set of SIM cards subject to a SIM policy. The format of the Activation Public Key that is included in the activation ticket is as shown in Table 2.

TABLE 1A

Format of Activation Ticket without SIM Policy

NAME	SIZE (Octets)	ENCODING
Version	1	BCD
Activation PublicKey	N	Public Key
ICCID	12	BCD
IMSI	8	BCD
IMEI	8	BCD
Hardware Thumbprint	20	Binary
TicketSignature	Key Length/8	Binary

TABLE 1B

Alternate Format of Activation Ticket with SIM Policy

NAME	SIZE (Octets)	ENCODING
Version	1	BCD
Activation PublicKey	N	Public Key
ICCID	12	BCD
IMEI	8	BCD
Hardware Thumbprint	20	Binary
SIM Policy Length	4	Integer-little endian
SIM Policy	SIM Policy Length	Binary
Padding	Variable	n/a
TicketSignature	Key Length/8	Binary

TABLE 2

Format of Activation Public Key

NAME	SIZE (Octets)	ENCODING
Record Length	4	Binary
Serial Number	4	Binary
KeyLength	4	Binary
Exponent	4	Binary
Modulus	Key Length/8	Binary
Montgomery Factor	Key Length/8	Binary
KeySignature	Mkey Length/8	Binary

In one embodiment, the Version field of the activation ticket **306/308** allows the processing of activation tickets to be forward compatible. In one embodiment, the encoded integer Version allows future firmware releases in the device **100** to recognize older activation tickets and support them. The Version is also included in the digest of the activation ticket to verify that it cannot be altered. In one embodiment, the BB **204** will have a minimum record version compiled into it that can prevent rollback attacks if an activation ticket format is compromised.

In one embodiment, the Activation Public Key field in the activation ticket **306/308** may be formatted as shown in Table 2. It should be noted, however, that other public key formats may be employed with departing from the scope of the claims that follow.

The ICCID (Integrated Circuit Card ID) is a 20-digit number, defined in ISO/IEC 7812-1 that consists of: a 2 digit major industry identifier (89 for SIMs), a 1-3 digit country code (ITU-T E.164), an issuer identifier code, 1-4 digits (depending on country code length), which usually contains the MNC of the issuing network, an individual account identification number, and a 1 digit checksum.

The IMSI (International Mobile Subscriber Identifier) is a 15-digit number, defined in 3GPP TS 23.003 that consists of a 3 digit mobile country code (MCC), a 2 or 3 digit mobile network code (MNC), and a 9 or 10 digit mobile subscriber identity number (MSIN).

In one embodiment, the GID values are documented in GSM 11.11 as files on the SIM card that contain identifiers for particular SIM-mobile equipment associations. The GID values are typically used to identify a group of SIM cards for a particular application.

In one embodiment, the Hardware Thumbprint is a value that is typically derived from data that is unique to the device, such as the serial numbers of the hardware components of the device and the IMEI, plus a defined random sequence. For example, in one embodiment the thumbprint may be computed as follows:

```
HardwareThumbprint =
   SHA-1(SGold-SerialNumber | | FlashSerialNumber
| | IMEI | | Salt),
```

where Salt is a random sequence.

In one embodiment, the Ticket Signature is generated as follows:

```
Message = Version | | ICCID | | IMSI | | IMEI | |
HardwareThumbprint
Hash = SHA-1(Message)
EncodedMessage = 0x00 | | 0x04 | | PaddingString | |
0x00 | | Hash
TicketSignature = RSAEncrypt(activationPrivateKey,
EncodedMessage)
```

In another embodiment, the Ticket Signature may be generated as follows:

```
Message = Version | | Activation Public Key | | ICCID
| | IMEI | | HardwareThumbprint | | SIM Policy Length
| | SIM Policy
Hash = SHA-1(Message)
EncodedMessage = 0x00 | | 0x04 | | PaddingString | |
0x00 | | Hash
TicketSignature = RSAEncrypt(activationPrivateKey,
EncodedMessage)
```

It should be noted that the described format of the activation ticket **306**/**308** set forth in Tables 1A and 1B are just two examples of formats that may be used, and other formats and data fields may comprise the activation ticket without departing from the scope of the claims that follow.

FIGS. **4**, **5**A, and **5**B are flow diagrams illustrating certain aspects of service provider activation according to one exemplary embodiment of the invention. In FIG. **4**, a method for a service provider signing process **400** is described. The method **400** to be performed begins at block **402**, in which the device **100** detects a baseband boot or the insertion of a new SIM card. At block **404**, the method **400** bundles some or all of the IMSI, GIDs, ICCID, IMEI and a hardware thumbprint into an activation request, and sends the request from the device to an activation server. At block **406**, the activation server receives the request, and determines whether to generate an activation ticket in response to the request based on certain policy considerations, such as whether the back end servers associated with the service provider confirm that the IMSI information is valid for the service provider's communication network, and/or whether there exists a SIM policy that can be encoded for a set of SIMs associated with the SIM card that triggered the request.

In one embodiment, at process block **408**, the method **400** generates the activation ticket for a SIM card or set of SIM cards using the ICCID, IMSI, GIDs, IMEI, and/or hardware thumbprint info illation that was bundled into the activation request.

In one embodiment, the method **400** includes encoding a SIM policy that describes a set of SIM cards that are allowed to be used with the device **100**. Whenever a new SIM card is inserted, the SIM policy is evaluated to determine whether that SIM is allowed. For purposes of SIM policy, each SIM card may be uniquely described by a tuple of the IMSI, GID**1**, and/or GID**2** identifiers. In a typical embodiment, the SIM policy is initialized to describe a null set. The SIM policy may be generated as an array of rules from which the mobile device **100** may derive a set of SIMs with which the device is allowed to be used. The array of rules may be encoded as in Table 3A as follows:

TABLE 3A

SIM Policy Rule Format

NAME	SIZE (Octets)	ENCODING
Flags	1	Binary
GID1	1	Binary
GID2	1	Binary
Unused	1	n/a
IMSI	8	BCD

where the Flags are encoded as in Table 3B as follows:

TABLE 3B

SIM Policy Flag Format

8	7	6	5	4	3	2	1
Include/ Exclude	GID1 Present	GID2 Present	Unused	Unused	Unused	Unused	Unused

In one embodiment, the include flag ("0") is used to describe SIMs that are part of the set of SIMs, whereas the exclude flag ("1") is used to describe SIMs that are not part of the set of SIMs. In one embodiment, the GID**1** and GID**2** flags are used to determine whether to ignore the GID fields ("0"—not present), i.e., to allow any GID value for that SIM, or whether to match to the GID fields ("1"—present), i.e., to require that the GID field on the SIM card match the GID encoded in the SIM policy on the stored activation ticket.

In one embodiment, the SIM policy encoded in the activation ticket may be used for a single SIM card lock to the same effect as if using the activation ticket format that does not encode a SIM policy (e.g., the format in Table 1A). In such case the SIM policy would include a single rule as in the example in Table 4 as follows:

TABLE 4

SIM Policy for a single SIM card lock

Rule Type	GID1	GID2	IMSI
Include	255	255	310410000000001

In one embodiment, the SIM policy encoded in the activation ticket may be used for a standard locked SIM card, as currently encoded in the SLF format, as in the example in Table 5, as follows (where the "*" indicates a wildcard match):

TABLE 5

SIM Policy for a standard SIM card lock

Rule Type	GID1	GID2	IMSI
Include	*	*	310150**********
Include	*	*	310170**********
Include	*	*	31041**********
Include	*	*	310180**********
Include	*	*	310980**********

In one embodiment, the SIM policy encoded in the activation ticket may be used for a totally unlocked SIM card, as in the example in Table 6, as follows (where the "*" indicates a wildcard match):

TABLE 6

SIM Policy for a totally unlocked SIM card

Rule Type	GID1	GID2	IMSI
Include	*	*	**********

In one embodiment, the SIM policy encoded in the activation ticket may be used to allow a SIM card where the SIM card is from any country where there is no carrier partner, while at the same time to allow a SIM Card from only certain countries where there is a designated carrier partner, e.g, (UK, US, Germany), as in the example in Table 7, as follows (where the "*" indicates a wildcard match):

TABLE 7

SIM Policy for a given SIM set S

Rule Type	GID1	GID2	IMSI
Include	*	*	**********
Exclude	*	*	234**********
Include	255	255	23410**********
Exclude	*	*	310**********
Include	255	255	310410**********
Exclude	*	*	262**********
Include	255	255	26201**********

In one embodiment, the method **400** encodes the ICCID field on the activation ticket as completely wildcarded in the case where more than one rule is being encoded in the SIM policy, or where a SIM Policy rule itself contains wildcards. This is to allow the matching multiple SIMS in a set of SIMs when using SIM policy during the activation process. Likewise, when the SIM policy record contains only one rule with no wildcards, the method **400** returns an activation ticket with the ICCID field as it was bundled in the original activation request with no wildcards so as to enhance security. When not encoding a SIM policy, the method **400** also returns the ICCID field as it was bundled in the original activation request.

In one embodiment, the method **400** includes inserting an activation public key into the ticket and, at block **410** signs the ticket using a corresponding activation private key that is securely stored on the activation server. At block **412**, the method **400** obscures the contents of the activation ticket by encrypting the contents with a device obfuscation key that is derived from information specific to the device, such as the hardware thumbprint provided in the activation request, and a shared obfuscation key that is available to both the activation server and the device. At process block **414**, the method **400** concludes with sending the activation ticket back to the device for storage. For example, the activation ticket may be stored in memory on the device that is accessible to the device's baseband.

Turning now to FIGS. **5**A-**5**B, a method for a service provider activation process **500** is described. The method **500** to be performed begins at block **502**, in which the device **100** queries the ICCID of the currently inserted SIM card at startup. At block **504**, the method **500** uses the ICCID to locate an activation ticket corresponding to the current ICCID. In some cases, the activation ticket corresponding to the current ICCID may contain a SIM policy, in which case the ICCID in the activation ticket has typically been wildcarded to allow for multiple SIM cards in a set of SIM cards to be activated by evaluating the SIM policy stored on that activation ticket against the current IMSI and GID values of the SIM card as described below in process block **514**. It should be noted that, in some cases, a GID file is not allocated in the SIM service table of the currently inserted SIM card, or there may be an error returned by the SIM card when reading the GID file. In that case, the GID values shall be treated as not present for purposes of evaluating the SIM policy in process block **514** as described below.

At block **506**, the device issues a command to initiate verification of the activation ticket. Verification of the activation ticket will cause the device's baseband to transition out of limited service mode and register on a communications network. The command will return an error code if the ticket cannot be successfully verified.

In a typical embodiment, the method **500** performs ticket verification after determining whether the SIM Card currently inserted into the device is in a ready state, i.e., whether the SIM is unlocked. If not, then the method **500** performs ticket verification after the SIM card has been successfully unlocked.

The method **500** continues at process blocks **508**A-**508**H, to perform the various aspects of activation ticket verification. At block **508**A, the method **500** first verifies that the retry count has not been exceeded. A retry counter will be incremented for each unsuccessful attempt to unlock and activate service on the device using the activation ticket verification command. Only a pre-defined number of attempts at verification are allowed to prevent against brute-force attacks, in which there are numerous attempts to activate the device.

In one embodiment, the method **500** continues at blocks **508**B/**508**C, to parse out the version information in the activation ticket from the encrypted information, and to determine whether the version of the activation ticket to be verified is supported in the current version of the device's baseband.

At block **508**D, the method **500** decrypts the contents of the activation ticket using a device obfuscation key that is derived from the shared obfuscation key stored on the device and information that is specific to the device, such as the device's hardware thumbprint. At block **508**E, the method **500** validates the activation public key supplied in the activation ticket, and at **508**F uses the public key to validate the ticket signature. At blocks **508**G/H, the method **500** concludes the ticket verification process by verifying whether the decrypted hash value of the activation ticket compares correctly to the computed hash value. If so, the method continues at process block **510**; otherwise the ticket verification fails and the method branches to block **516**.

At process block **510**, in order to prevent an activation ticket from one device being used on another device, the IMEI in the activation ticket is compared to the IMEI stored in the device. In one embodiment, all 15 digits of the respective IMEIs must match. If they do not, the BB activation ticket

At process block **512**, the method **500** continues to verify the activation ticket by determining the value of the hardware thumbprint contained in the activation ticket, and comparing that to the hardware thumbprint of the device. If they do not match, the activation ticket is treated as invalid.

At process block **514**, the method **500** continues to verify the activation ticket by comparing the value of the ICCID contained in the activation ticket to the ICCID of the SIM card currently inserted in the device. In special cases, the ICCID verification is bypassed, such as when the ICCID is encoded with 10 0xFF octets. Similarly, at process block **514**, the method **500** continues to verify the activation ticket by comparing the value of the IMSI contained in the activation ticket to the IMSI of the SIM card currently inserted into the device. Again, in special cases, the IMSI verification is bypassed, such as when the IMSI is encoded with 10 0xFF octets.

In one embodiment, at process block **514**, the method **500** continues to verify the activation ticket by evaluating the IMSI and GID values of the SIM card currently inserted into the device against the SIM policy data encoded into the activation ticket. Note that if a GID is not present in the SIM card (or is otherwise unable to be read) and a GM is specified as present in a rule in the array of rules in the SIM policy, then the rule will be treated as non-matching, and the value of the GID in the rule will not be checked.

In a typical embodiment, using the array of rules contained in the SIM policy of the activation ticket, the method **500** builds an identifier set I of allowable SIMs from primitive sets defined in the rules using the include and exclude operations as specified in the corresponding flags of the rules. For example, a primitive set P is defined as a number which may

contain wildcard digits (using BCD encoding) that expand to all digits "0-9." The identifier set I is composed of all identifiers which match the given pattern. The two primitive set operations either add members of the primitive set to the identifier set (e.g., I=I∪P), or remove them (e.g., I=I∩P). Once the identifier set I is built, the method **500** can then determine whether the currently inserted SIM card is a member of the identifier set.

In a typical embodiment, because the exclude operation is not commutative, the rules in the array of rules in the SIM policy are ordered. As such, during evaluation of the SIM policy, the method **500** need not build any data structures in which to store an identifier set I, but may instead set an indicator, e.g, "is Member," as to whether the currently inserted SIM card is a member of the identifier set defined in the SIM policy of the activation ticket using the following pseudocode example:

```
isMember = False
for each P in rules
   if C is in P
      if rule->Exclude
         isMember = False
      else
         isMember = True
      end if
   end if
end for
```

At process block **516**, the method increments the retry counter and returns an error in response to the command should any of the activation ticket verification processes fail. At process block **518**, if the verification processes are successful, then the device can activate service on the device by initiating registration of the device on the service provider's mobile communication network.

FIG. **6** illustrates an example of a typical computer system in which some aspects of the invention may be practiced, such as the backend clients and servers used to provide service activation of a mobile device. Note that while FIG. **6** illustrates various components of a computer system, it is not intended to represent any particular architecture or manner of interconnecting the components as such details are not germane to the present invention. It will also be appreciated that network computers and other data processing systems which have fewer components or perhaps more components may also be used with the present invention. The computer system of FIG. **6** may, for example, be a Macintosh computer from Apple Computer, Inc.

As shown in FIG. **6**, the computer system **601**, which is a form of a data processing system, includes a bus **602** which is coupled to a microprocessor(s) **603** and a ROM (Read Only Memory) **607** and volatile RAM **605** and a non-volatile memory **606**. In one embodiment, the microprocessor **603** may be a G3 or G4 microprocessor from Motorola, Inc. or one or more G5 microprocessors from IBM. The bus **602** interconnects these various components together and also interconnects these components **603**, **607**, **605**, and **606** to a display controller and display device **604** and to peripheral devices such as input/output (I/O) devices which may be mice, keyboards, modems, network interfaces, printers and other devices which are well known in the art. Typically, the input/output devices **609** are coupled to the system through input/output controllers **608**. The volatile RAM (Random Access Memory) **605** is typically implemented as dynamic RAM (DRAM) which requires power continually in order to refresh or maintain the data in the memory. The mass storage **606** is typically a magnetic hard drive or a magnetic optical drive or an optical drive or a DVD RAM or other types of memory systems which maintain data (e.g. large amounts of data) even after power is removed from the system. Typically, the mass storage **606** will also be a random access memory although this is not required. While FIG. **6** shows that the mass storage **606** is a local device coupled directly to the rest of the components in the data processing system, it will be appreciated that the present invention may utilize a non-volatile memory which is remote from the system, such as a network storage device which is coupled to the data processing system through a network interface such as a modem or Ethernet interface. The bus **602** may include one or more buses connected to each other through various bridges, controllers and/or adapters as is well known in the art. In one embodiment the I/O controller **608** includes a USB (Universal Serial Bus) adapter for controlling USB peripherals and an IEEE 1394 controller for IEEE 1394 compliant peripherals.

It will be apparent from this description that aspects of the present invention may be embodied, at least in part, in software. That is, the techniques may be carried out in a computer system or other data processing system in response to its processor, such as a microprocessor, executing sequences of instructions contained in a memory, such as ROM **607**, RAM **605**, mass storage **606** or a remote storage device. In various embodiments, hardwired circuitry may be used in combination with software instructions to implement the present invention. Thus, the techniques are not limited to any specific combination of hardware circuitry and software nor to any particular source for the instructions executed by the data processing system. In addition, throughout this description, various functions and operations are described as being performed by or caused by software code to simplify description. However, those skilled in the art will recognize what is meant by such expressions is that the functions result from execution of the code by a processor, such as the microprocessor **603**.

What is claimed is:

1. A machine implemented method of activating a mobile device, the method comprising:

issuing an activation request, the activation request comprising device data that uniquely identifies a mobile device, the device data comprising an International Mobile Equipment Identifier (IMEI) encoded in the mobile device;

storing in the mobile device a signed activation record comprising the device data and a subscriber identity module (SIM) policy data containing an array of rules that identifies a set of SIM cards that may be used with the mobile device;

verifying the activation record against a SIM card in accordance with the SIM policy data, including determining that the SIM card belongs to the identified set of SIM cards that may be used with the mobile device;

where the SIM card includes a subscriber identifier associated with the SIM card, the subscriber identifier further comprising an International Mobile Subscriber Identifier (IMSI) that designates the subscriber authorized to use the SIM card; and

registering the device with a communications network using the SIM card.

2. The method of claim **1**, wherein the device data that uniquely identifies the mobile device includes a hardware thumbprint of the mobile device.

3. The method of claim **2**, wherein the hardware thumbprint of the mobile device is derived from at least one of: (i) a serial number of a baseband component in the mobile device,

(ii) a serial number of a memory component of the mobile device, (iii) a serial number of the mobile device.

4. The method of claim **1**, wherein the device data that uniquely identifies the SIM card includes a serial number of the SIM card.

5. The method of claim **4**, wherein the serial number of the SIM card is an Integrated Circuit Card ID (ICCID) encoded on the SIM card.

6. The method of claim **1**, wherein the device data that uniquely identifies the SIM card includes a group identifier associated with the SIM card.

7. The method of claim **6**, wherein the group identifier associated with the SIM card is a Group Identifier (GID) that identifies the SIM card as belonging to a group of SIM cards.

8. A non-transitory machine-readable storage medium storing program instructions that, when executed, cause a data processing system to:

issue an activation request, the activation request comprising device data that uniquely identifies a mobile device;

store in the mobile device a signed activation record comprising the device data and a subscriber identity module (SIM) policy data containing an array of rules describing one or more conditions which must be successfully evaluated for SIM cards before use with the mobile device;

verify the activation record against a SIM card in accordance with the SIM policy data, including determining that the SIM card belongs to an identified set of SIM cards that may be used with the mobile device; and

register the device with a communications network using the SIM card.

9. The non-transitory machine-readable storage medium of claim **8**, wherein the device data that uniquely identifies the device includes a hardware thumbprint of the device.

10. The non-transitory machine-readable storage medium of claim **8**, wherein the device data that uniquely identifies the device includes a serial number of the mobile device.

11. The non-transitory machine-readable storage medium of claim **8**, wherein the serial number of the mobile device is an International Mobile Equipment Identifier (IMEI) encoded in the mobile device.

12. The non-transitory machine-readable storage medium of claim **8**, wherein a SIM card is identified by a serial number of the SIM card.

13. The non-transitory machine-readable storage medium of claim **12**, wherein the serial number of the SIM card is an Integrated Circuit Card ID (ICCID) encoded on the SIM card.

14. The non-transitory machine-readable storage medium of claim **8**, wherein the SIM card is identified by a subscriber identifier associated with the SIM card.

15. A machine implemented method of activating a mobile device, the method comprising:

receiving an activation request, the activation request comprising device data that uniquely identifies a mobile device, the device data comprising an International Mobile Equipment Identifier (IMEI) encoded in the mobile device;

generating a signed activation record comprising the device data and a subscriber identity module (SIM) policy data containing an array of rules describing one or more conditions which must be successfully evaluated for SIM cards before use with the mobile device;

where each SIM card includes a subscriber identifier associated with the SIM card, the subscriber identifier further comprising an International Mobile Subscriber Identifier (IMSI) that designates the subscriber authorized to use the SIM card; and

transmitting the signed activation record to the mobile device;

wherein the mobile device is configured to store the signed activation record responsive to receipt.

16. The machine implemented method of claim **15**, wherein the activation request additionally identifies a SIM card.

17. The machine implemented method of claim **16**, further comprising verifying the activation request.

18. A machine implemented method of activating a mobile device, the method comprising:

issuing an activation request comprising device data encoded in the device that uniquely identifies a mobile device;

storing in the mobile device a signed activation record comprising the device data and a subscriber identity module (SIM) policy data containing rules that identifies SIM cards that may be used with the mobile device;

verifying the activation record against a SIM card in accordance with the SIM policy data, including determining that the SIM card belongs to the identified SIM cards that may be used with the mobile device, the SIM card including an International Mobile Subscriber Identifier (IMSI) that designates the subscriber authorized to use the SIM card; and

registering the device with a communications network using the SIM card.

19. A non-transitory machine-readable storage medium storing program instructions that are configured to, when executed on a data processing system, cause the data processing system to:

issue an activation request, the activation request comprising device data that uniquely identifies a mobile device;

store in the mobile device a signed activation record comprising the device data and a subscriber identity module (SIM) policy data containing rules describing one or more conditions which must be successfully evaluated for SIM cards before use with the mobile device;

verify the activation record against a SIM card in accordance with the SIM policy data, including determining that the SIM card belongs to a population of SIM cards that may be used with the mobile device; and

register the device with a communications network using the SIM card.

20. A machine implemented method of activating a mobile device, the method comprising:

receiving an activation request comprising device data that uniquely identifies a mobile device, the device data comprising an International Mobile Equipment Identifier (IMEI) encoded in the mobile device;

generating a signed activation record comprising at least a portion of the device data and a subscriber identity module (SIM) policy data containing one or more rules before use with the mobile device;

where each SIM card includes a subscriber identifier associated with the SIM card, the subscriber identifier further comprising an International Mobile Subscriber Identifier (IMSI) that designates the subscriber authorized to use the SIM card; and

transmitting the signed activation record to the mobile device;

wherein the mobile device is configured to store the signed activation record responsive to receipt.

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